



Research Article

Osmopriming and Straw Mulching Improve Wheat Productivity under Water-Limited Conditions in the Old Brahmaputra Floodplain of Bangladesh

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ARTICLE INFO	ABSTRACT
Article history Received: 02 September 2026 Accepted: 25 September 2026 Published: 30 September 2026 Keywords <i>Triticum aestivum</i>; osmopriming; polyethylene glycol; straw mulch; crown-root initiation Correspondence Ahmed Khairul Hasan ✉: akhasan@bau.edu.bd OPEN ACCESS	Water scarcity during the critical stages of crop establishment and reproductive development can substantially constrain wheat (<i>Triticum aestivum</i> L.) productivity in the Rabi season of Bangladesh. Seed priming promotes early germination and metabolic activity, while residue mulching helps conserve soil moisture and reduce evaporation. A field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from November 2023 to March 2024 to evaluate the individual and combined effects of seed priming and water-management practices on wheat productivity. The experiment was arranged in a split-plot design with three replications, comprising four seed-priming treatments and four water-management practices. Water management was assigned to main plots: no irrigation (W_0), one irrigation at crown-root initiation (W_1), two irrigations at crown-root initiation and at flowering (W_2) and straw mulching at 6 t ha^{-1} (W_3). Seed priming was assigned to subplots: no priming (P_0), hydropriming with distilled water (P_1), osmopriming with 13.5% polyethylene glycol (PEG) solution (P_2) and halopriming with 1% CaCl_2 solution (P_3). Osmopriming consistently enhanced germination, plant growth, tillering, and dry matter accumulation compared with the unprimed control. It also produced the highest grain yield (4.06 t ha^{-1}), straw yield (4.98 t ha^{-1}), and biological yield (9.04 t ha^{-1}) among priming treatments. Straw mulching similarly improved crop growth and productivity, producing 4.03 t ha^{-1} grain yield compared with 2.87 t ha^{-1} under no irrigation. The combination of straw mulching and PEG osmopriming (W_3P_2) produced the highest grain yield (4.48 t ha^{-1}) and biological yield (9.54 t ha^{-1}), whereas the unprimed, non-irrigated treatment (W_0P_0) produced only 2.46 and 5.64 t ha^{-1}, respectively. These findings demonstrate that integrating PEG osmopriming with straw mulching can enhance wheat productivity under water-limited field conditions and provide a practical water-saving management option for wheat production in the Old Brahmaputra Floodplain of Bangladesh.
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Introduction

Wheat (*Triticum aestivum* L.) is a strategic cereal crop that underpins food and nutritional security across much of the world, yet its cultivation is increasingly constrained by the availability of water. In Bangladesh, wheat is the second most important staple after rice, but domestic supply falls far short of demand: the country produced only 1.23 MMT in 2023 while importing 3.87 MMT to bridge the gap (Rahman et al., 2024). This shortfall is closely tied to the crop's vulnerability during the dry rabi season, when wheat is grown from November to March under a precipitation-free window and often with limited or no irrigation (Jahan et al., 2025).

Globally, freshwater scarcity has become one of the defining challenges for cereal production. Drought is widely recognized as the most prominent abiotic constraint on wheat, with drought conditions reported to reduce grain yield by between 30 and 62.75% (Jahan et al., 2025). In Bangladesh, water scarcity alone accounts for roughly 30% of wheat production losses, and about 3.5 million hectares of land are considered drought-vulnerable (Ansari, 2020; Das et al., 2024). The problem is especially acute in the Old Brahmaputra Floodplain and other northern and central wheat belts, where nearly one-third of the wheat area is rainfed (Jahan and Ahmed, 2018). Reliance on groundwater has intensified sharply the share of irrigated land served by surface water fell from 76% in 1981 to 23% in 2012,

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while groundwater dependence climbed from 16% to 80% (Rahman et al., 2024). This approach is neither ecologically nor economically sustainable, making water-saving strategies an urgent priority for the region.

Among soil-based interventions, straw mulching has proven highly effective at conserving soil moisture. It increased soil water storage at sowing by 23.6–84.5 mm in 2008 and 51.0–83.2 mm in 2009 in dryland winter wheat (Zhang et al., 2015), raised grain yield by 29.8% and 35.6% across two seasons (Javed et al., 2020), and under straw strip mulching improved water use efficiency by 21.6% and grain yield by 16.5% (Li et al., 2022). Such mulches reduce evaporative loss and moderate the soil microclimate, thereby stretching scarce water further.

Seed priming operates through a different route preparing the seed physiologically before stress is encountered. Priming is a controlled hydration followed by re-drying that initiates germination-related metabolism without allowing radicle emergence (Devika et al., 2021). Hydropriming is the simplest and most economical form, while halopriming uses inorganic salts and osmopriming relies on high-molecular-weight solutes such as polyethylene glycol (Pawar and Laware, 2018). These methods are not functionally equivalent. Osmoprimed bold wheat seeds improved stand establishment, crop growth rate and leaf area index under both well-watered and drought conditions (Hussain, 2018), PEG osmopriming raised transpiration rate by 29% and relative water content by 3.5% at anthesis and improved the highest grain yield by 82.7% in one cultivar (Aldahadha et al., 2024), and halopriming induced a lasting "stress memory" that improved grain yield and water use efficiency under deficit irrigation (El-Sanatawy et al., 2021).

Despite this body of evidence, priming and mulching have largely been evaluated in isolation. Few field studies have tested how priming agents and straw mulch interact when applied together under the water-limited conditions typical of the Old Brahmaputra Floodplain. This gap matters because a seed-level treatment and a soil-level treatment act on different parts of the same water balance, and their combined effect cannot be assumed to be additive. This study therefore aimed to evaluate how different seed-priming techniques, including hydro-, osmo-, and halopriming, interact with water-management practices, particularly straw mulching, to influence wheat productivity under water-limited field conditions. Specifically, the study sought to identify the most effective priming technique for improving wheat productivity and to determine how priming and water-management practices, individually and in combination, affect wheat performance and productivity under drought-stressed conditions.

Materials and Methods

Experimental site and crop environment

The experiment was conducted at Bangladesh Agricultural University (BAU), located at 24°04' N latitude and 90°50' E longitude, at an elevation of 18 m above sea level. The site falls within the Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) (UNDP and FAO, 1988). The experimental field was medium-high land with silty clay loam soil (pH 6.8) and classified as non-calcareous dark-grey floodplain soil. The region has a subtropical climate, with high temperature, humidity, and rainfall during the Kharif season (April–September), whereas the Rabi season (October–March) is characterized by relatively low temperature, limited rainfall, and abundant sunshine. Weather conditions during the crop-growing period are presented in **Figure 1**, while the soil physicochemical properties are provided in **Table 1**.

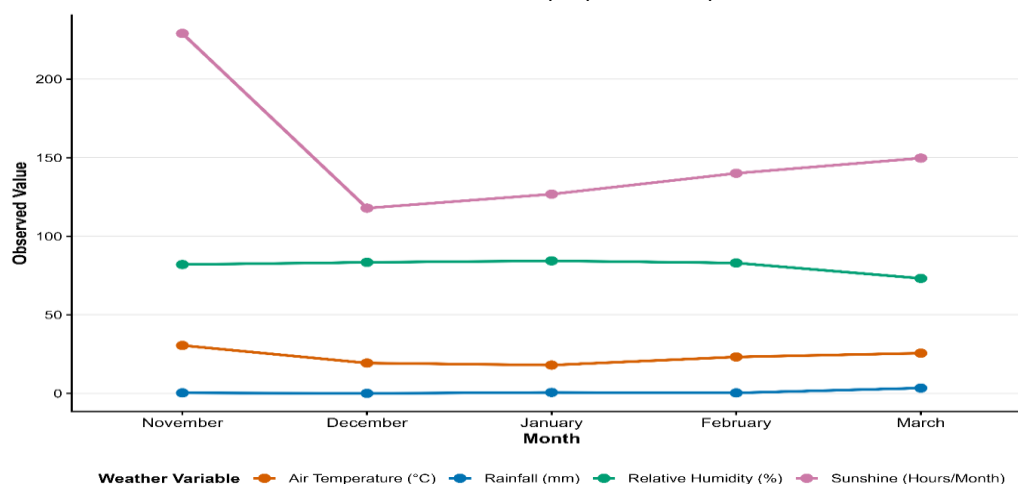


Fig. 1: Monthly average air temperature, rainfall, relative humidity, and sunshine hours during growing season.

Table 1: Physical and chemical properties of the initial soil (0-15 m depth)

Physical	Result	Chemical	Result
Sand (%) (0.0-0.02 mm)	20	pH	6.4
Silt (%) (0.02-0.002 mm)	67	Organic matter (%)	1.67
Clay (%) (<0.002 mm)	13	Total nitrogen (%)	0.101
Soil textural class	Silt loam	Available sulphur (ppm)	13.9
Particle density (g/cc)	2.6	Available phosphorous (ppm)	26
Bulk density (g/cc)	1.35	Exchangeable potassium (me %)	0.14
Porosity (%)	46.67	Available zinc	0.5

Plant material

The wheat cultivar used in the experiment was BARI Gom 26, a short-duration variety released by BARI in 2010. It has broad, deep-green leaves and medium-sized spikes, producing about 45-50 grains per spike with a 1000-grain weight of 48-52 g. It takes about 60-65 days to reach heading and 104-110 days to mature. The variety is resistant to leaf rust and tolerant to Bipolaris leaf blight and terminal heat stress, making it suitable for both normal and late sowing.

Treatments and experimental design

The experiment was conducted using two factors. Factor A was priming technique, consisting of four treatments: P_0 = no priming (Control), P_1 = hydropriming with distilled water, P_2 = osmopriming with 13.5% PEG solution, and P_3 = halopriming with 1% CaCl_2 solution. Factor B was water management, comprising four treatments: W_0 = no irrigation, W_1 = one irrigation at the crown root initiation (CRI) stage, W_2 = two irrigations at the CRI and flowering stages, and W_3 = rice straw mulching at 6 t ha⁻¹. The experiment followed a split-plot design with three replications, where water management treatments were assigned to the main plots and priming treatments to the subplots.

Crop husbandry

Land preparation was done using tractor drawn rotary plough for wheat production. Urea, TSP, MoP, and gypsum were applied at 200, 160, 50, and 112 kg ha⁻¹, respectively. Two-thirds of urea and the full amounts of TSP, MoP, and gypsum were applied during final land preparation, while the remaining urea was applied at 35 DAS. Seeds of wheat cultivar BARI Gom 26 were collected from BADC, Mymensingh, and sown on 22 November 2016 at 120 kg ha⁻¹ with a depth of 5 cm, maintaining a row-to-row spacing of 20 cm. Rice straw mulch was applied after sowing, before crop emergence, according to the respective treatment. Hand weeding was done three times, with gap filling on 3 December. Irrigation was provided at the CRI stage (20 DAS) and flowering stage according to the treatments, with excess water drained when necessary.

No insect or disease control was required. The crop was harvested on 15 March 2017. After harvesting, each plot's crop was separately dried, threshed, cleaned, and weighed for grain and straw yield.

Data recording

For the laboratory germination test, 100 seeds from each priming treatment were placed in four Petri dishes. Germination was recorded on the 4th and 8th days after seed placement, and the germination percentage was calculated. Growth data consisted of plant height at 15, 30 and 45 days after sowing (DAS), number of total tillers hill⁻¹ at 30 and 45 DAS and total dry matter at 15, 30, 45 and 60 DAS. Yield contributing traits at harvest were total tillers (hill⁻¹), effective tillers (hill⁻¹), leaves per plant (no.), spike length (cm), spikelets spike⁻¹, filled and unfilled grains spike⁻¹, 1000-grain weight (g), grain yield (t ha⁻¹), straw yield (t ha⁻¹), biological yield (t ha⁻¹) and harvest index (t ha⁻¹). The harvest index was calculated as follows ():

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

The data were analyzed using R software (version 4.5.2) following a split-plot design. The main-plot error was used for water management, while the subplot error was used for seed priming. Duncan's Multiple Range Test (DMRT) was used at the 5% significance level to separate treatment means (Gomez and Gomez, 1984).

Results

Seed germination response to priming

Seed priming clearly improved seed germination compared with unprimed seeds. At 4 days after placement, germination was highest with osmopriming (91%), followed by hydropriming (82%) and halopriming (73%), while the control recorded only 51%. By 8 days, osmopriming maintained the highest germination (96%), followed by halopriming (90%) and hydropriming (89%) (Figure 2).

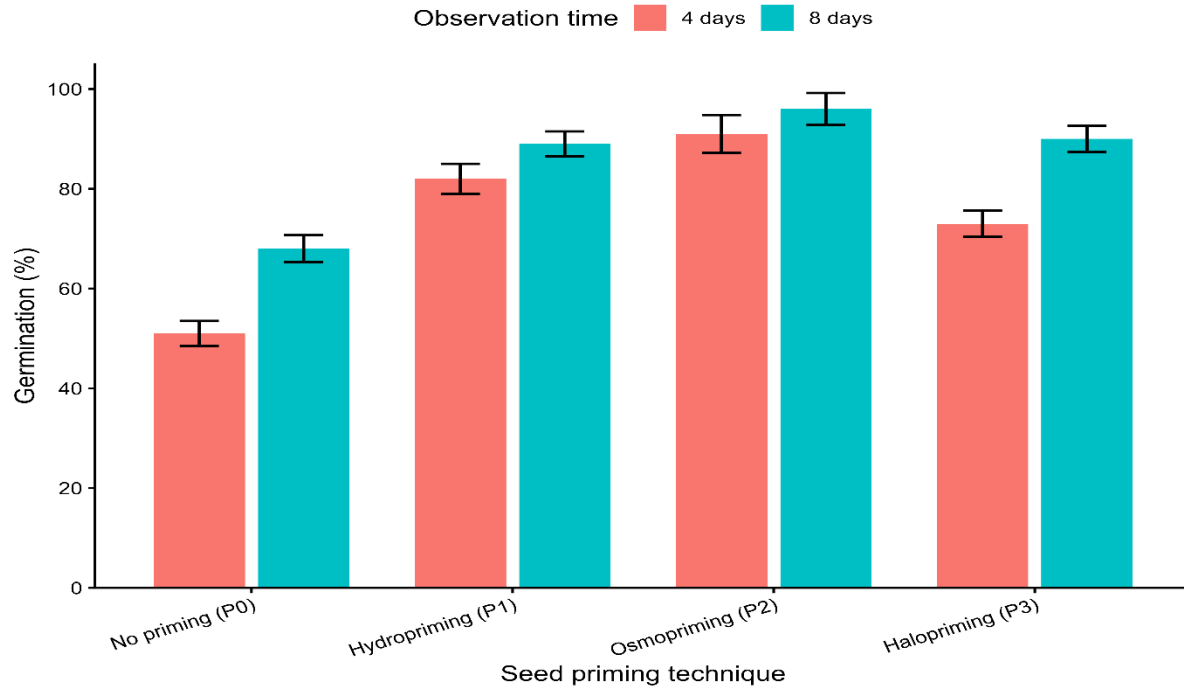


Fig. 2: Effect of different seed priming on seed germination of wheat.

Growth response to seed priming

Plant height was significantly influenced by different seed priming techniques at 15, 30 and 45 DAS. Findings showed that at 15, 30 and 45 DAS, the tallest plant was observed in osmopriming (29.80 cm, 42.92 cm and 74.18 cm, respectively) while the shortest plant height was observed in no priming (P₀) condition (26.21 cm, 38.00 cm and 68.14 cm, respectively) (Table 2). Seed priming significantly affected the number of tillers hill⁻¹ at both observation dates. Osmopriming (P₂) produced

the highest number of tillers at 30 DAS (3.50) and 45 DAS (4.67), whereas no priming (P₀) recorded the lowest values (2.08 and 3.00, respectively) (Table 2). Seed priming significantly affected total dry matter production at all observation dates. Osmopriming (P₂) consistently recorded the highest values at 15, 30, 45, and 60 DAS (2.63, 2.04, 15.19, and 17.22 g, respectively), while no priming (P₀) showed the lowest values (2.32, 1.46, 10.97, and 10.68 g, respectively).

Table 2. Effect of Seed Priming on Growth Parameters of Wheat

Priming	Plant Height (cm)			Total Tillers hill ⁻¹ (no.)		Total Dry Matter (g)			
	15 DAS	30 DAS	45 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS	60 DAS
P ₀	26.21b	38.00b	68.14b	2.08d	3.00d	2.32c	1.46d	10.97b	10.68c
P ₁	27.19b	40.68c	69.73b	2.58c	3.58c	2.43b	1.62c	12.87c	14.02b
P ₂	29.80a	42.92a	74.18a	3.50a	4.67a	2.63a	2.04a	15.19a	17.22a
P ₃	28.75a	41.75b	73.25a	3.08b	4.08b	2.57a	1.85b	14.44b	14.62b
Sx	0.517	0.310	0.933	0.047	0.056	0.030	0.027	0.222	0.311
LSD (0.05)	1.51	0.90	2.72	0.137	0.163	0.088	0.079	0.65	0.91
Level of sig.	**	**	**	**	**	**	**	**	**
CV (%)	6.40	2.62	4.54	5.85	5.02	4.21	5.45	5.75	7.65

Where, Means followed by different letters within a column indicate significant differences according to DMRT at $P \leq 0.05$. TDM = total dry matter. P₀ = no priming (Control), P₁ = hydropriming with distilled water, P₂ = osmopriming with 13.5% PEG solution, and P₃ = halopriming with 1% CaCl₂ solution.

Growth response to water management

Water management significantly influenced plant growth and dry matter production, except for plant height at 45 DAS. Straw mulch (W_3) produced the tallest plants at 15 and 30 DAS (30.02 and 44.17 cm, respectively), while the non-irrigated treatment (W_0)

recorded the shortest (26.61 and 38.08 cm). At 30 and 45 DAS, W_3 also produced the highest number of tillers hill⁻¹ (3.08 and 4.50) and total dry matter at 15, 30, 45, and 60 DAS (2.75, 2.22, 17.04, and 15.46 g, respectively), whereas W_0 consistently recorded the lowest values (Table 3).

Table 3. Effect of different water management on Growth Parameters of Wheat

Water	Plant Height (cm)			Total Tillers hill ⁻¹		Total Dry Matter (g)			
	15 DAS	30 DAS	45 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS	60 DAS
W_0	26.61b	38.08b	68.89	2.58c	3.08d	2.31c	1.47d	11.10d	12.57d
W_1	27.47b	40.14bc	70.05	2.75bc	3.75c	2.40bc	1.59c	12.06c	13.54c
W_2	27.86b	40.96b	72.87	2.83b	4.00b	2.49b	1.68b	13.27b	14.97b
W_3	30.02a	44.17a	73.49	3.08a	4.50a	2.75a	2.22a	17.04a	15.46a
Sx	0.463	0.706	1.650	0.051	0.053	0.032	0.024	0.235	0.142
LSD (0.05)	1.60	2.44	5.71	0.176	0.183	0.111	0.083	0.81	0.49
Level of sig.	**	**	NS	**	**	**	**	**	**
CV (%)	5.74	5.99	8.01	6.27	4.81	4.40	4.81	6.10	3.48

Where, Means followed by different letters within a column indicate significant differences according to DMRT at $P \leq 0.05$. TDM = total dry matter. W_0 = No irrigation, W_1 = One irrigation at CRI stage, W_2 = Two irrigation at CRI and flowering stage, W_3 = Mulching with straw @ 6 t ha⁻¹

Effects of priming on yield and yield components

Seed priming significantly influenced most yield-related traits of rice, except harvest index (Table 4). The number of filled grains spike⁻¹ increased progressively with priming, from 43.98 in the non-primed control (P_0) to 46.27 in PEG osmopriming (P_2) and 46.00 in CaCl₂ halopriming (P_3). A similar pattern was observed for number of spikelets spike⁻¹, which increased from 15.06 in P_0 to 15.74 in P_2 , followed by 15.61 in P_3 . Grain yield showed a more pronounced response to priming. PEG osmopriming (P_2) produced the highest grain yield (4.06 t ha⁻¹), whereas lowest found in the control priming

(3.03 t ha⁻¹). CaCl₂ halopriming (P_3) also substantially improved grain yield to 3.70 t ha⁻¹, whereas hydropriming resulted in 3.38 t ha⁻¹. The highest straw yield was recorded under PEG osmopriming (P_2) at 4.98 t ha⁻¹, whereas the lowest was observed in no priming (P_0) at 3.74 t ha⁻¹. Similarly, P_2 (PEG osmopriming) produced the highest biological yield (9.04 t ha⁻¹), while the lowest was recorded in P_0 (no priming) at 6.78 t ha⁻¹. In contrast, harvest index was not significantly affected by seed priming, ranging from 44.11% (P_1) to 44.80% (P_2).

Table 4. Effect of seed priming on yield and yield-related traits

Priming	Filled grains spike ⁻¹ (no)	Spikelets spike ⁻¹ (no.)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest Index (%)
P_0	43.98c	15.06b	3.03d	3.74d	6.78d	44.60
P_1	45.17b	15.39ab	3.38c	4.24c	7.62c	44.11
P_2	46.27a	15.74a	4.06a	4.98a	9.04a	44.80
P_3	46.00ab	15.61a	3.70b	4.61b	8.32b	44.49
LSD (0.05)	0.93	0.49	0.093	0.196	0.222	1.30
Level of sig.	**	*	**	**	**	NS
CV (%)	2.45	3.81	3.09	5.29	3.33	3.48

Where, Means followed by different letters within a column indicate significant differences according to DMRT at $P \leq 0.05$. TDM = total dry matter. P_0 = no priming (Control), P_1 = hydropriming with distilled water, P_2 = osmopriming with 13.5% PEG solution, and P_3 = halopriming with 1% CaCl₂ solution.

Effects of different water management on yield and yield components

Water management significantly influenced all yield and yield-related traits of wheat. The number of filled grains spike⁻¹ increased from 44.43 under W_0 (no irrigation) to 46.19 under W_3 (straw mulching @ 6 t ha⁻¹), with W_3 recording the highest value. Similarly, spikelets spike⁻¹

increased from 15.26 in W_0 to 15.64 in W_3 . Grain yield followed the same trend, with the highest yield under W_3 (4.03 t ha⁻¹) and the lowest under W_0 (2.87 t ha⁻¹). W_2 (two irrigations at CRI and flowering stages) produced 3.93 t ha⁻¹, while W_1 (one irrigation at CRI stage) produced 3.34 t ha⁻¹. Straw and biological yields were also highest under W_3 , reaching 4.76 and 8.80 t

ha⁻¹, respectively, compared with the lowest values of 4.00 and 6.88 t ha⁻¹ under W₀. The higher productivity under straw mulching may be associated with improved soil moisture conservation throughout crop growth.

Harvest index was highest under W₂ (47.05%), followed by W₃ (45.79%), whereas W₀ recorded the lowest value (41.87%) (Table 5).

Table 5. Effect of seed priming on yield and yield-related traits

Water Management	Filled grains spike ⁻¹ (no)	Spikelets spike ⁻¹ (no.)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest Index (%)
W ₀	44.43b	15.26b	2.87c	4.00c	6.88d	41.87b
W ₁	45.27ab	15.36b	3.34b	4.35b	7.69c	43.29b
W ₂	45.53a	15.54a	3.93a	4.46b	8.40b	47.05a
W ₃	46.19a	15.64a	4.03a	4.76a	8.80a	45.79a
Sx	0.300	0.034	0.039	0.086	0.108	0.469
LSD (0.05)	1.04	0.118	0.135	0.298	0.37	1.62
Level of sig.	*	**	**	**	**	**
CV (%)	2.29	0.78	3.78	6.76	4.75	3.65

Where, Means followed by different letters within a column indicate significant differences according to DMRT at P ≤ 0.05. TDM = total dry matter. P₀ = no priming (Control), P₁ = hydropriming with distilled water, P₂ = osmopriming with 13.5% PEG solution, and P₃ = halopriming with 1% CaCl₂ solution.

Interaction between seed priming and water management on growth and yield contributing traits of wheat

The interaction between water management and seed priming significantly affected spikelets spike⁻¹, grain yield, straw yield, biological yield, and harvest index, whereas plant height, effective tillers hill⁻¹, and filled grains spike⁻¹ were not significantly influenced by the interaction (Table 6). Plant height ranged from 91.27 cm (W₀P₀) to 103.07 cm (W₃P₂), while effective tillers hill⁻¹ varied from 3.40 (W₀P₀) to 4.13 (W₃P₂). Although W₃P₃ showed the highest numerical values for both traits, the interaction was non-significant, indicating that these differences were not statistically reliable. Similarly, filled grains spike⁻¹ ranged from 42.21 in W₀P₀ to 46.72 in W₃P₂, but the interaction effect was non-significant. For spikelets spike⁻¹, the interaction was

significant, with the W₃P₂ is numerically highest at 15.82 and is statistically comparable with W₂P₂, while W₀P₀ recorded the lowest (14.73). Grain yield responded strongly to the combined treatments. The highest grain yield was obtained from W₃P₂ (4.48 t ha⁻¹), followed by W₂P₂ (4.40 t ha⁻¹), whereas W₀P₀ produced the lowest yield (2.46 t ha⁻¹). Straw yield was highest under W₂P₂ (5.10 t ha⁻¹) and lowest under W₀P₀ (3.18 t ha⁻¹). Biological yield showed a similar response, reaching 9.54 t ha⁻¹ under W₃P₂ compared with only 5.64 t ha⁻¹ under W₀P₀. In contrast, harvest index was highest with W₂P₁ (49.01%), while the lowest value occurred under W₀P₁ (39.26%). Overall, the combination of straw mulching (W₃) with PEG osmopriming (P₂) produced the highest grain and biological yields, demonstrating a favorable interaction for wheat productivity.

Table 6. Interaction effect of water management and seed priming on key yield-contributing characters and yield of wheat

Interaction	Plant height (cm)	Effective tillers hill ⁻¹ (no.)	Spikelets Spike ⁻¹ (no.)	Filled grains Spike ⁻¹ (no.)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest Index (%)
W ₀ × P ₀	91.27	3.40	14.73e	42.21	2.46i	3.18f	5.64h	43.56defg
W ₀ × P ₁	93.60	3.43	15.16d	43.82	2.62hi	4.05de	6.66fg	39.26h
W ₀ × P ₂	101.47	3.73	15.69ab	45.95	3.31fg	4.73abc	8.04c	41.14gh
W ₀ × P ₃	97.40	3.65	15.47bc	45.73	3.12g	4.06de	7.18e	43.50defg
W ₁ × P ₀	93.33	3.43	14.86e	43.53	2.70h	3.72e	6.42g	41.98fgh
W ₁ × P ₁	93.93	3.60	15.26cd	45.52	3.13g	4.30cd	7.43de	42.16efg
W ₁ × P ₂	102.67	3.90	15.71a	46.10	4.06bc	5.03ab	9.09a	44.68cdef
W ₁ × P ₃	98.93	3.77	15.62ab	45.93	3.47ef	4.35cd	7.82cd	44.36cdef
W ₂ × P ₀	93.47	3.50	15.26cd	44.47	3.39f	3.71e	7.09ef	47.75ab
W ₂ × P ₁	94.33	3.67	15.47bc	45.55	3.85d	4.03de	7.88cd	49.01a
W ₂ × P ₂	102.87	3.98	15.76a	46.30	4.40a	5.10a	9.50a	46.43abcd
W ₂ × P ₃	100.07	3.83	15.67ab	45.80	4.11bc	5.02ab	9.13a	45.01bcde
W ₃ × P ₀	93.67	3.60	15.40c	45.72	3.60e	4.38cd	7.98c	45.11bcde
W ₃ × P ₁	96.47	3.77	15.66ab	45.80	3.92cd	4.60bc	8.52b	46.00bcd
W ₃ × P ₂	103.07	4.13	15.82a	46.72	4.48a	5.06a	9.54a	46.96abc
W ₃ × P ₃	102.40	3.93	15.68ab	46.54	4.13b	5.03ab	9.16a	45.10bcde
Sx	3.02	0.093	0.068	0.640	0.063	0.134	0.153	0.894
LSD (0.05)	8.81	0.271	0.198	1.87	0.184	0.39	0.45	2.61
Level of sig.	NS	NS	**	NS	**	**	**	**
CV (%)	5.39	4.35	0.78	2.45	3.09	5.29	3.33	3.48

Where, Means followed by different letters within a column indicate significant differences according to DMRT at P ≤ 0.05. TDM = total dry matter. P₀ = no priming (Control), P₁ = hydropriming with distilled water, P₂ = osmopriming with 13.5% PEG solution, and P₃ = halopriming with 1% CaCl₂ solution.

Discussion

The present study demonstrates that combining seed priming with appropriate water-management practices can substantially improve wheat performance under water-limited field conditions. Seed priming markedly improved wheat germination, with osmopriming (P₂) showing the strongest response. Osmoprimed seeds of wheat maintained higher emergence counts than dry seeds for both bold and small seed lots under normal irrigated and water-stressed conditions, with early and more uniform stand establishment attributed to quicker germination and emergence arising from elevated enzyme activation and an early start to seed metabolism (Hussain, 2018).

Osmopriming produced the greatest plant height, tiller number and total dry matter at the measured growth stages, whereas unprimed plants generally showed the lowest values. The superiority of PEG osmopriming over the other agents is also consistent with published comparisons. In durum wheat, osmopriming with either PEG or CaCl₂ significantly improved growth and yield parameters compared with hydropriming, and osmopriming was reported to be more effective than hydropriming because it improved relative water content and transpiration rate under anthesis drought (Aldahadha et al., 2024). These outcomes align with previous research indicating that priming techniques significantly bolster productive tiller density and overall yield capacity compared to untreated seeds (Ali et al., 2013). This physiological adjustment likely facilitates more efficient nutrient uptake and deeper root penetration, which are critical for sustaining physiological processes during moisture-restricted growth periods (Meena et al., 2014). Osmopriming also improved filled grains, spikelets, grain yield, straw yield and biological yield, while harvest index remained statistically unchanged. Furthermore, the enhanced grain yield observed across varied water availability levels suggests that primed seeds effectively optimize moisture use, likely through improved root architecture and superior stand establishment (Aldahadha et al., 2024).

Water management significantly affected crop growth, with straw mulch (W₃) producing the highest values for most growth traits. The application of straw mulch appears to mitigate moisture stress by reducing evaporative losses, thereby optimizing soil water relations for sustained nutrient uptake throughout critical phenological phases (Ranazai et al., 2024). Straw mulching produced the highest grain, straw and biological yields, reaching 4.03, 4.76 and 8.80 t ha⁻¹, respectively. Improved water conservation under mulch likely sustained crop growth during moisture-sensitive

periods by enhancing the soils water-holding capacity and creating a more favorable microclimate for root development (Usman et al., 2024). These results confirm that integrated nutrient and moisture management strategies are essential for stabilizing productivity under fluctuating irrigation regimes (Rehman et al., 2011; Ali et al., 2023).

The significant interaction for grain, straw and biological yields indicates that seed priming and water management did not operate entirely independently. W₃P₂ produced the highest grain yield (4.48 t ha⁻¹) and biological yield (9.54 t ha⁻¹), whereas W₀P₀ produced only 2.46 and 5.64 t ha⁻¹, respectively. This complementary response suggests that physiological preparation of the seed and conservation of soil moisture can reinforce crop performance under water-limited conditions by facilitating a synergistic environment where enhanced early-stage vigor allows the crop to better exploit the moisture conserved by mulching practices (Bana et al., 2018; Singh et al., 2026). Such synergistic benefits are likely mediated by improved root distribution and enhanced dry matter remobilization, which collectively bolster the crop's capacity for sustained nitrogen uptake even under periodic moisture deficits (Ru et al., 2025). The superior performance of W₃P₂ may therefore reflect two complementary processes: PEG priming improved seed physiological readiness, while straw mulch helped maintain moisture after establishment, thereby bridging the critical gap between early-season germination vigor and later moisture availability during the grain-filling stage (Yin et al., 2019; Al-Khafagi, 2025).

These findings indicate that combining seed priming with residue-based moisture conservation could be a practical strategy for improving wheat productivity where irrigation water is constrained.

Conclusion

The study demonstrated that seed priming and water management substantially influenced wheat growth and productivity under water-limited field conditions. Among the priming treatments, PEG osmopriming (13.5%) consistently produced superior germination, plant growth, tillering, dry matter accumulation, and yield performance, resulting in the highest grain yield of 4.06 t ha⁻¹. Straw mulching at 6 t ha⁻¹ was the most productive water-management practice, achieving a grain yield of 4.03 t ha⁻¹. The interaction between the osmopriming and straw mulching at 6 t ha⁻¹ was significant for major yield components and yield. Overall, integrating PEG osmopriming with straw mulching offers a promising approach for improving wheat productivity where irrigation water is limited,

particularly under the agro-ecological conditions of the Old Brahmaputra Floodplain of Bangladesh.

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